Calculation of Detection Efficiency of Volume Source at a Horizontal Geometry by EXVol Code

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1. Introduction

The radio activity measurement of highly radioactive waste or bulky object is a difficult process due to the preparation of the sample and the risk of radiation exposure. By introducing a detector scanning concept that measures the radiation at a specific location by installing a collimator, it can lower the intensity of radioactivity and the detection efficiency distribution can be obtained from the nondestructive measurement of the source. To calculate the full energy (FE) absorption peak efficiency for arbitrary volume sample, we developed and verified the EXVol (Efficiency calculator for eXtended Voluminous source) code which is based on effective solid angle method [1]. The procedure for semi-empirical determination of the FEP efficiency for the arbitrary volume sources and the calculation principles about EXVol code were validated in previous study [2]. In this study, the performance of the EXVol code was extended to obtain the detection efficiency distribution at a specific position and energy at a horizontal geometry.

2. Methods

The standard volume source was described as 3-dimensional (x,y,z) cylindrical source at a horizontal geometry. It is shown in Figure 1. A collimator was placed between source and detector to consider the scanning and detecting at a specific position in a large volume source. The input values for defining the collimator include matter, density (g/cm^3), hole diameter (mm) and thickness (mm) of a collimator. The definition of a collimator is shown in Figure 2.

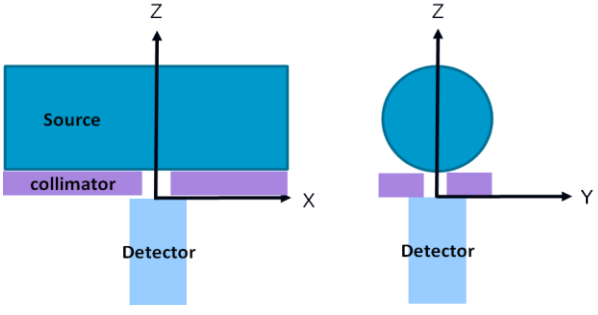

Fig. 1. Coordinate system of horizontal geometry.

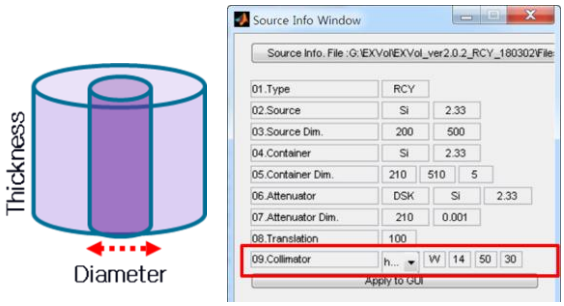

Fig. 2. Definition of a collimator and input value in the EXVol code.

To calculate the asymmetric structure, the radial direction of the volume source was assumed to be uniform. The x- coordination of the detector center was set to 0 and translation of the detector was considered by the direction and distance of movement. If the detector is moved to the left side of the source, minus value of the translated distance is entered to the EXVol code and if the detector is moved to the right side of the source, plus value of the translated distance is entered to the EXVol code.

To verify the performance of the EXVol, we calculated the detection efficiency of 15.7 *l* Si ingot volume source with HPGe detector. Detector translation was +100 mm and source was divided 20 pieces in the x-, y- and z- direction respectively. Calculation information is summarized in Table 1.

Table I: Calculation for performance test of EXVol

	Contents	
Simulation	**Γ-ray generation: 10^7, Translation: +100**	
Detector	**n-type coaxial HPGe, Relative efficiency : 32%**	
Source	**Si ingot**	**Density: 2.33 [g.cm^{-3}]**
	Diameter: 200 [mm] **Height: 500[mm]** **Total volume: 15,700,000 [mm^3] (= 15.7 [*l*])** **Differential volume** **→ Divided 20 pieces in the x-, y- and z-directions**	
Energy	**200 -1500 [keV]**	

3. Results

The results of this study were shown below in contour plots. Translation of the detector in the x-, y- and z- axis direction was corresponds to the YZ, ZX and XY plane respectively. Each plane and coordinates defined in the calculation were shown in Figure 3.

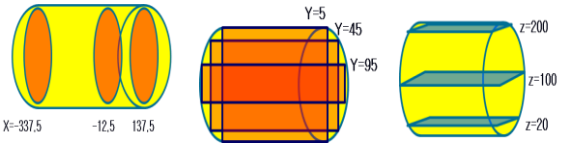

Fig. 3. The reference position of each plane for contour plot.

2.1 Distribution of detection efficiency of YZ plane

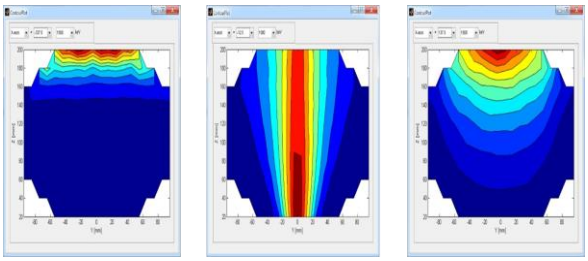

Fig. 4. Calculation results according to x-position translation. X= -337.5, -12.5 and 137.5 respectively (From left to right)

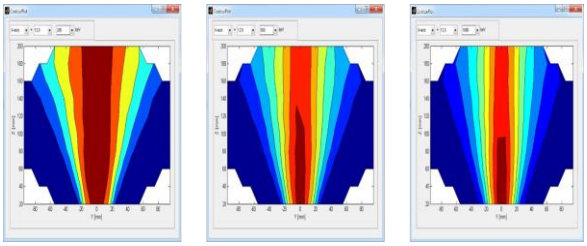

Fig. 5. Calculation results according to g-ray energy. 200, 500 and 1500 keV respectively (From left to right)

2.2 Distribution of detection efficiency of ZX plane

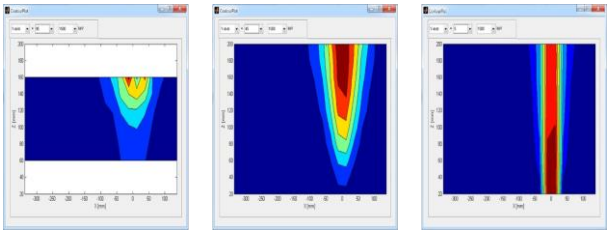

Fig. 6. Calculation results according to y-position translation. Y= 95, 45 and 5 respectively (From left to right)

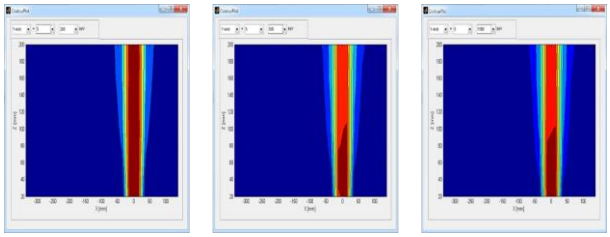

Fig. 7. Calculation results according to g-ray energy. 200, 500 and 1500 keV respectively (From left to right)

2.3 Distribution of detection efficiency of XY plane

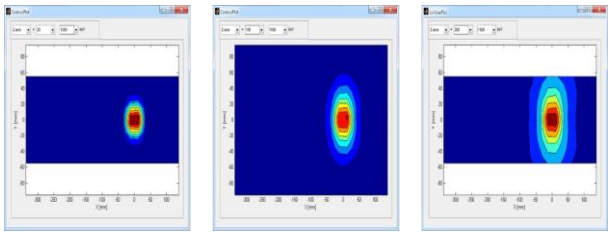

Fig. 8. Calculation results according to z-position translation. Z= 20, 100 and 200 respectively (From left to right)

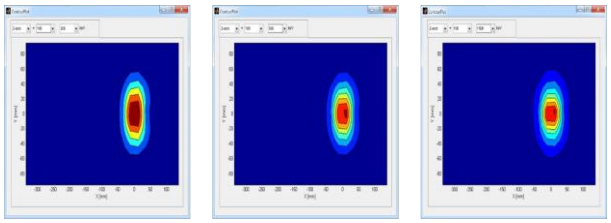

Fig. 9. Calculation results according to g-ray energy. 200, 500 and 1500 keV respectively (From left to right)

3. Conclusions

We have established a method for calculating the detection efficiency of the differential volume corresponding to a specific position in the source. As a result of this study, γ-ray detection efficiency and radiation distribution were obtained in the large volume and high density medium source at a horizontal geometry.

REFERENCES

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